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PROCESSING AND MECHANICAL BEHAVIOUR OF HUMAN HAIR FIBER REINFORCED POLYMER COMPOSITES

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ABSTRACT

This paper presents the mechanical properties of human hair strengthened epoxy composites. The effect of fiber stacking and length on mechanical properties like tensile strength, flexural strength, impact strength and hardness of composites is inspected. Tests were conducted on polymer composites with various substance of human hair fiber i.e. 0%, 10%, 20%, 30% and with moving length of human hair i.e. 0.5, 1, 1.5 and 2 cm. By testing of composites, it has been observed that there is critical impact of human hair reinforcement on the mechanical properties of composites. The detailed test outcomes and results are presented and conclusions are drawn.

KEYWORDS: Human Hair, Matrix, Reinforcement & Mechanical Behaviour

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Original Article

INTRODUCTION

In view of the change and advancement of development, the need of material having significantly specific properties is growing well-ordered, and this test intrigue can't be fulfilled by the usage of polymers, dirt and metal composites. Likewise, starting late composite materials are used as elective, as piece of a couple of light weight and fantastic applications. Composites are normally happening or planned materials, which are delivered from at least two constituents. All things considered, composites materials have strong weight pass on fortifying material imbedded in weaker system materials. In composites, the broken stage is known as the fortification, which is normally harder and more grounded than the network, which is called constant stage. The grid material keeps the fortifications in the coveted area and introduction. The support used to enhance general mechanical properties of lattice and offer quality to composites of network and offer quality to composites. The constituents of composite materials have their property, anyway, when they are consolidated, they give a blend of properties that a solitary can't have the ability to give.

Composite materials can be arranged in view of the sorts of lattice utilized as:-

- Ceramic Matrix Composites (CMC)
- Metal Matrix Composites (MMC)
- Polymer Matrix Composites (PMC)

Among different kinds of composites, PMC is the most usually utilized composites, because of its numerous favourable circumstances, for example, basic assembling rule, minimal effort and high quality. PMCs have two sorts of polymer that have been utilized as grid. These are thermoplastics and thermosetting polymer. Thermoplastic polymer is that polymer, which are more than once mollified and improved by warming. A few cases of thermoplastics are PVC, LDPE and HDPE.

Thermosetting polymer is the polymer, which has hard and hardened cross-connected materials. They are not diminished and malleable when they are warmed. Epoxy is the most generally utilized thermosetting polymer.

As of late, the normal strands are picking up enthusiasm as fortification in polymer composites quickly. The normal fiber utilized as fortification from extremely old fashion, as man utilized grass and straw from start of development in strengthening the blocks that are utilized to influence mud to divider. There are numerous points of interest of normal fiber over customary fortifying material, accordingly as low thickness, minimal effort, upgraded vitality recuperation, great warm properties, adequate particular quality and biodegradable [1]. These strands are effectively and plentifully accessible, biodegradable, and these focal points make regular fiber well known over manufactured fiber, for example, glass fiber, carbon and other man-made filaments. Regular strands are normally happening materials, comprising of cellulose fibrils inserted in lignin network.

The structure of some usually utilized common strands appears in Table 1, based on the wellspring of beginning, the regular filaments are portrayed into three orders. They are,

- Mineral Fibers
- Animal Fibers
- Plant Fibers

Mineral Fibers

Mineral filaments are the generally happening fiber or possibly balanced strands, procured from minerals. It has diverse characterizations they are taking after: Asbestos is the primary generally happening mineral fiber. The Variations in mineral fiber are the anthophyllit e, amphiboles and serpentine. The Ceramic strands are aluminum oxide, glass filaments, boron carbide and silicon carbide. Metal strands consolidate aluminums filaments.

Animal Fibers

Animal fiber generally includes proteins; delineations mohair, wool, silk, alpaca. Creature hairs are the strands got from creatures e.g. horse hair, Sheep's downy, goat hair, alpaca hair, et cetera. Silk fiber is the filaments assembled from dried spit of frightening little animals for the duration of the season of preparation of spreads. Avian filaments are the strands from flying animals. Delineations silk is from silk worms.

Table 1

Fiber	Lignin (%Wt.)	Hemi-Cellulose (%Wt.)	Cellulose (%Wt.)	Moisture (%Wt.)	Pectin (%Wt.)	Waxes (%Wt.)
Cotton	-	5.7	85 to 90	7.85 to 8.5	0 to 1	0.6
Bamboo	32	0.5	60.8	-	-	-
Flax	2.2	18.6 to 20.6	71	8 to 12	2.3	1.7
Kenaf	8 to 13	21.5	45 to 47	-	3 to 5	-

Table 1: Contd.,						
Jute	12 to 13	13.6 to 20.4	61 to 71.5	12.5 to 14	0.2	0.5
Hemp	3.7 to 5.7	17.9 to 20.4	70 t 74	6.2 to 12	0.9	0.8
Ramie	0.6 to 0.7	13.1 to 16.7	68.6 to 76	7.5 to 17	1.9	0.3
Coir	40 to 45	0.15 to 0.25	32 to 43	8	3 to 4	-
Sisal	10 to 14	10 to 14	66 to 78	10 to 22	10	2
Banana	5	10	63 to 64	10 to 12	-	-

Plant Fibers

Plant strands generally contain cellulose: representations cotton, flax, jute, ramie, sisal and hemp. Cellulose filaments are used as a piece of the produce of paper and material. The arrangement of these strands is taking after: Seed filaments are the strands procure from the seed case and seed e.g. kapok and cotton. Leaf filaments are the strands got from the leaves e.g. agave and sisal. Skin strands are the filaments got from the skin or bast incorporating the stem of the plant [2]. This strand has higher flexibility than various filaments. In like manner, these strands are used as a piece of strong yarn, texture, packaging, and paper. Tree developed sustenance strands are the filaments got from the results of the dirt of the plant, e.g. coconut (coir) fiber. Stalk fiber are the filaments that are obtained from the stalks of the plant. Trademark fiber composites are not new to humankind. Presently, the regular fiber fortified polymer composites applications for the most part are found in vehicle ventures and building industry and where, the dimensional security and load conveying quality under sodden and warm dependability conditions is imperative. For instance, flax fiber based polyolefin are generally utilized as a part of car industry.

Here, the fiber goes about as a fortification in non basic inside [3]. Characteristic fiber fortified polymer composites are utilized for auxiliary applications, however, for the most part with engineered thermoset, grid material is used, which restrict the natural advantages [4, 5]. The normal fiber composites are extremely financial savvy material for the given applications:

- **For the Furniture:** shower, Seat, Table, and so Forth.
- **For the Electrical Gadgets:** Power Apparatuses and so on.
- **For the Day by Day Utilize:** Bags, Lampshades, and so on.
- **For the Transportation:** Vehicle Ventures and Railroad Mentors, Vessel and so Forth.

Fortification in polymer is either engineered or regular. Engineered filaments, for instance, glass, and carbon are utilized for polymer composites; anyway, their fields of utilizations are limited on account of mind-boggling expense. Regular filaments have numerous favourable circumstances over manufactured strands. The potential usage of various characteristic filaments for polymer composites has just been investigated. Among different characteristic strands, human hair has numerous focal points. Human hair has strong mouldable property; in this manner, it could be used as a fiber support material. It gives incredible property at simpler cost of age. It also makes natural issue for its weakening, due to its non-degradable properties. To this end, an endeavour has been made to contemplate the potential usage of human hair, which is financially and easily found in India for making esteem included items. The goal of present work is to assess the mechanical properties of human hair fortified epoxy composites. The effect of fiber stacking and length on mechanical properties like rigidity, flexural quality, affect quality and hardness of composites is inspected.

LITERATURE SURVEY

Hair is a proteinaceous fiber, with a firmly various levelled association of subunits from the α-keratin chains, by means of middle of the road fibers to the fiber [6]. The uncommon properties of human hair, for example, its extraordinary substance piece, moderate corruption rate, high rigidity, warm protection, flexible recuperation, flaky surface, and one of a kind associations with water and oils has prompted numerous different employments. Volkin et al. [7] distinguished and portrayed the procedures prompting obliteration of cystine deposits. They analyzed proteins from various species, including those of thermophilic microorganisms living close to the breaking point of water.

Thompson [8] produced a hair-based composite material, by controlling a majority of trim lengths of hair to shape a web or tangle of hair, and consolidating said web or tangle of hair with an auxiliary added substance to frame said composite material. Jain et al. [9] examined on hair fiber fortified concrete and presumed that there is colossal augmentation in properties of cement, as per the rates of hairs by weight of in concrete. The expansion of human hairs to the solid enhances different properties of solid like elasticity, compressive quality, restricting properties and miniaturized scale breaking control, and furthermore increments spalling obstruction. Subsequently, human hairs are in relative wealth in nature and are non-degradable, giving another time in field of FRC.

Hu et al. [10] considered on Protein-based composite biomaterials, which can be framed into an extensive variety of biomaterials with tunable properties, including control of cell reactions. They gave new biomaterials, which is an essential need in the field of biomedical science, with guide pertinence to tissue recovery, nano prescription and ailment medications. Human hair is considered as a waste material in many parts of the world, and it is found in civil waste streams which cause various environmental issues. Gupta [11] considered on Human Hair "Waste" and Its Utilization. Through this, it has been reasoned that the human hair has countless in regions, going from agribusiness to drug to designing ventures. Hernandez et al. [12] contemplated on keratin, which is a fiber that is found in hair and quills.

Keratin fiber has a various levelled structure with an exceedingly requested adaptation, is independent from anyone else; a biocomposite, result of an expansive development of creature species. Through this, it has been reasoned that the keratin strands from chicken quills demonstrates an eco-accommodating material, which can be connected in the advancement of green composites. Babu et al. [13] examined on bio-based polymers and presumed that, it has generally expanded the consideration because of natural concerns and the acknowledgment that, worldwide oil assets are limited.

MATERIALS AND METHODOLOGY

Matrix Material

Among differing sorts of structure materials, polymer systems are the most by and large used, in perspective of various purposes of enthusiasm. For instance, cost suitability, straight forwardness of produce with less tooling rate and like manners have noteworthy room temperature properties. Polymer systems could be thermoplastic or thermosetting. The most regularly used thermosetting gums are epoxy, polyester, vinyl ester, Polyurethanes and phenolics. Among them, the epoxy tar is the most ordinarily utilized polymer, because of various purposes of enthusiasm, for instance, tremendous connection to wide grouping of fibers, pervasive mechanical and electrical properties and extraordinary execution at lifted temperatures. Despite that, they have low shrinkage in the wake of restoring and extraordinary manufactured security. On account of different purposes of enthusiasm over other thermoset polymers, epoxy is picked as the cross section material for the present examination work. It artificially fits in with the "epoxide" family, and its consistent name of epoxy is

Bisphenol-A-Diglycidyl-Ether [14, 15].

Fibre Material

The regular fiber human hair is taken out from the nearby sources. It is a fiber, which is effectively and inexpensively accessible in India. Filaments, by and large, are used as a piece of bond for the going with reasons:

- To control breaking, in view of both plastic shrinkage and drying shrinkage.
- Furthermore, they diminish the permeability of concrete, and thus reduce depleting of water.
- A couple of sorts of strands in like manner create more tremendous impact, scratched territory, and crush wellbeing in bond.
- The fineness of the strands licenses them to brace the mortar division of the bond, delaying split surrounding and spread. This fineness also curbs depleting in the strong, therefore lessening permeability and upgrading the surface properties of the hardened surface.

Hair is used as a fiber invigorating material in concrete, for the going with reasons:

- It has a high flexibility, which is equal to that of a copper wire with similar width.
- Hair, a non-degradable issue is making an environmental issue, so, its use as a fiber strengthening material can limit the issue.
- It is also available in rich and easily.
- It strengthens the mortar and shields it from spalling.

Composite Fabrication

The human hair fiber is accumulated from nearby sources. Epoxy is taken as lattice material. The low temperature relieving epoxy and the comparing hardener are mixed in a level of 10:1 by weight as endorsed. A form of size 210×210×40 mm^3 is used for creation of composites. The human hair strands are mixed with epoxy by the fundamental mechanical blending. The composites are set up with three unmistakable fiber stacking and four particular fiber lengths, using hand lay-up process.

The blend is put into various moulds, changing in accordance with the necessities of various testing conditions and portrayal models. The assignment and detailed structure of composites are introduced in Table 2. The cast of every composite is shielded under a heap of around 20 kg for 24 hours. By then, this cast is post relieved coursing, wherever for an extra 24 hours in the wake of removing out of the form. At long last, the examples of appropriate measurements are cut for mechanical tests.

Table 2: Designation of Composites

Composites	Compositions
C1	Epoxy (90wt. %)+ Hair fiber (fiber length0. 5mm) (10wt. %)
C2	Epoxy (80wt. %)+ Hair fiber (fiber length0. 5mm) (20wt. %)
C3	Epoxy (70wt. %)+ Hair fiber (fiber length 0.5mm) (30wt. %)
C4	Epoxy (90wt. %)+ Hair fiber (fiber length1mm) (10wt. %)
C5	Epoxy (80wt. %)+ Hair fiber (fiber length1mm) (20wt. %)
C6	Epoxy (70wt. %)+ Hair fiber (fiber length 1mm) (30w.t%)

C7	Epoxy (90wt. %)+ Hair fiber (fiber length1. 5mm) (10wt. %)
C8	Epoxy (80wt. %)+ Hair fiber (fiber length1. 5mm) (20wt. %)
C9	Epoxy (70wt. %)+ Hair fiber (fiber length 1.5mm) (30wt. %)
C10	Epoxy (90wt. %)+ Hair fiber (fiber length2.0mm) (10wt. %)
C11	Epoxy (80wt. %)+ Hair fiber (fiber length2.0mm) (20wt. %)
C12	Epoxy (70wt. %)+ Hair fiber (fiber length 2.0mm) (30wt. %)

Figure 1: Human Hair Fiber

Figure 2: Human Fiber Reinforced Epoxy Composite

Mechanical Testing of Composites

The mechanical properties of composite are relying upon various factors like, fiber stacking and fiber length. As indicated by ASTM D3039-76 test models, the tractable trial of composites is done using Universal Testing Machine Instron 1195. A heap was associated with the two sides of composite examples for the testing. The trial set up and the example for ductile test is presented in Figure 3 and 4, separately.

The flexural trial of composites is additionally done, using Universal Testing Machine Instron 1195. The discoveries of flexural quality ought to be the basic portrayal of a composites material. For the testing, the cross head rate is kept as 2 mm for every min, and a traverse of 60 mm is kept up. The stacking plan for flexural test is introduced in Figure 5. The effect tests are done according to ASTM D 256, utilizing an effect analyzer. The exploratory set up for affect test is presented in Figure 6.

Figure 3: Experimental Setup of Tensile Test

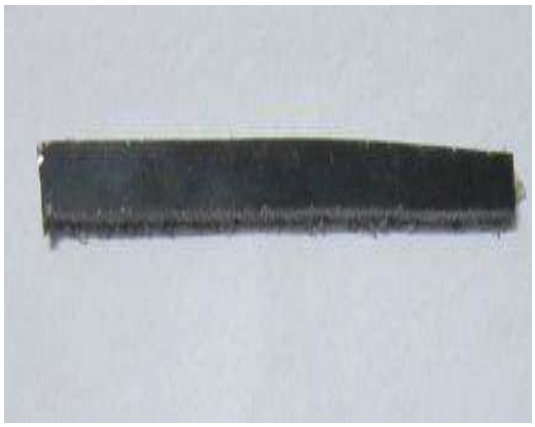

Figure 4: Specimen for Tensile Test

Figure 5: Loading Arrangement for Flexural Test

Figure 6: Experimental Setup of Impact Test

RESULTS & DISCUSSIONS

Mechanical Behaviour of Composites

The Influence of Fibre Parameters on Tensile Strength of Composites

The impact of fiber parameters on rigidity of composites is appears in Figure 7. It is discovered that, for composites with 10% fiber stacking, the rigidity, at first increases with increment in fiber length up to 1 cm, and after that begins diminishing. Furthermore, for 20% fiber stacking, the elasticity increases with increment in fiber length up to 1.5 cm, and after that begins diminishing. What's more, for 30% fiber stacking, the elasticity increases with the expansion in fiber length up to 1.5 cm and afterward diminishes.

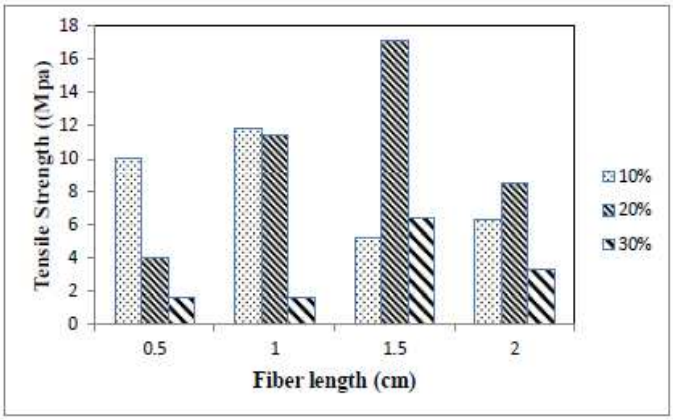

Figure 7: Effect of Fibre Parameters on Tensile Strength of Composites

The Influence of Fiber Parameters on Flexural Strength of Composites

The impact of fiber parameters on flexural quality of composites appears in Figure 8. It is discovered that for composites with 10% fiber stacking, the flexural quality increase up to 1.5 cm of fiber length and after that begins diminishing. What's more, for 20% fiber stacking, the flexural quality increase up to 1.5 cm of fiber length, and after that begins diminishing. Furthermore, for 30% fiber stacking, the flexural quality at first increases up to 1 cm of fiber length and after that begins diminishing.

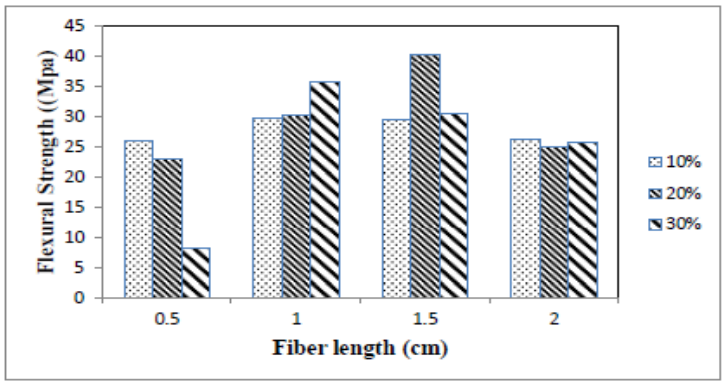

Figure 8: Effect of Fibre Loading and Length on Flexural Strength of Composites

The Influence of Fiber Parameters on Impact Strength of Composites

The influence of fiber parameters on impact strength of composites is shown in Figure 9.

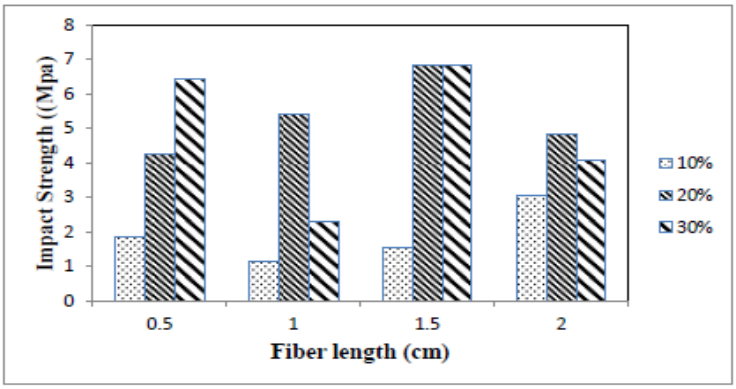

Figure 9: The Influence of Fiber Parameters On Impact Strength of Composites

It is discovered that, for composites with 10% fiber stacking, the effect of quality, at first, declines with increase in fiber length up to 1 cm and after that begins expanding. Furthermore, for 20% fiber stacking, the effect of quality of composites increases with increment in fiber length up to 1.5 cm and after that begins diminishing. What's more, for 30% fiber stacking, there is no normal pattern is found.

CONCLUSIONS

The trial examination on the mechanical conduct of human hair fiber based epoxy composites demonstrates the accompanying conclusions:

- In this work, the productive generation hair fiber based epoxy composites, with different fiber lengths and stacking is conceivable.
- It ought to be perceived that the fiber parameters, for example, fiber stacking and length has basic effect on the mechanical properties of the composites.
- The mechanical property like flexural quality, elasticity and effect of quality outcomes are discovered best for composites, strengthened with 20wt% fiber stacking with 1.5cm fiber length.

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